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ABSTRACT

This paper focuses on mathematics education in Technical and Vocational Education (TVE) in West Germany. The "dual system" of TVE, a part-time college/part-time on-the-job training scheme that normally leads to a certificate of a qualified worker after three years, is reviewed. Entrance tests for the trainee posts focus heavily on aspects of mathematics. Qualifications tested include: decimals and various fractions; proportions; change of measurements; rule of three; percentages; and some geometry. Lessons for selected students center around topics such as basic arithmetic, percentages, and proportions. Special areas for particular occupations covered include graph-, table-, and diagram-reading and interpreting, basic algebra, and advanced calculating techniques. Criticisms concerning this topic-oriented approach are presented. (MP)

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Apprenticeship and College - Mathematics in Technical and Vocational Education ("TVE")

1. Technical and Vocational Education in the FRG

The Federal Republic of Germany has a complicated system of part-time and full-time courses in technical and vocational colleges. These schemes prepare students for their entry into the labor market and aim at rather different qualification levels, providing preparatory education for very different vocations. Bluntly stated, this education is structured as follows: The lower the qualification level to be attained, the higher the proportion of on-the-job-training paralleled by part-time schooling. In my contribution, I will concentrate on the approximately 50 % of the youth who attend these part-time college/part-time on-the-job-training schemes which lead to a certificate of a qualified worker. For these schemes I will use the word "dual system" of TVE (for details cf. BLUM, STRAESSER).

During the normal three years of this "dual system" scheme, the student or apprentice attends college courses for 1 to 2 days weekly; the rest of the week he will be in private firms and be trained on-the-job to a varied extent. During these three years, 1 or 2 of his approximately 8 hours of (weekly) college attendance will be devoted to lessons which offer mathematical topics. These are meant to be taught in close relation to situations of the vocation the apprentice is trained for.

2. Mathematics in TVE for Lower Qualification Levels

2.1 Entrant Tests Set by Employers

Comparable to other industrialized countries, there is a shortage of places in the dual system in the FRG. So the employers set entrant tests in order to select the applicants for these trainee-posts. In these tests, mathematics

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plays a very important role. Research about the qualifications tested shows that the tests concentrate on numeracy (arithmetic with decimals and to a various extent fractions; proportions; change of measurements, rule of three) percentages and some geometry. There are no standardized tests offered for this special purpose. Sometimes they even set tests with apparently no predictive value nor mathematical or psychological background (for all these findings cf. LOERCHER).

2.2 Implemented Mathematics Curriculum in West-German TVE

As there is no empirical study analysing the mathematics lessons really taught in West-German TVE I will give a brief survey of what ought to be the contents of the lessons in the dual system - judging from syllabi and textbooks.

Mathematics lessons center around topics as basic arithmetic, percentages and proportions (rule of three, etc.). In some vocations, these techniques already seem to be all mathematics needed and they are applied in these lessons to a great variety of situations taken from the vocation the student prepares for. In addition to this "core of topics" which is present in all vocations, there are some specific topics which depend on the vocation the student is trained for: basic algebra (especially the manipulation of formulae), table-, diagram- and graph-reading and interpreting and some more advanced calculating techniques and problems as logarithms, exponential functions and trigonometry. They are added to the curriculum for metal workers, apprentices in the electrotechnical and electronics field as well as for those going into careers in constructing vocations. Commerce apprentices are being trained for business calculations including calculation of interests, discount rates, and securities. Some basic descriptive statistics is now entered in these commerce curricula. Geometry and technical drawing plays an important role in constructing vocations (metal and wood workers, bricklayers).

Most of these topics may have been touched upon or learnt in compulsory education before. The greatest difficulty for the students (apprentices) seems to be the application of these techniques to vocational situations, as can be seen in the results of the final examinations at the end of this vocational training. The search and identification of the right way to solve a vocational problem - the "mathematization of the vocational situation" - turns out to be twice as difficult as the calculation itself (cf. PLOGHAUS, p. 524). Apprentices often fail because they cannot correctly relate mathematics and the vocational situation, they have not learnt to APPLY mathematics.

3. Criticism concerning the Topic-Oriented Approach

3.1 Arguments from Research in Mathematics in TVE

Going through the reports published on research in the field and discussing with people doing the research work, one often hears about the problem of really determining the needs of industry and commerce: German researchers complained explicitly about the problem of finding the right person to indicate the needs. The same statement seems to be true for the English research work, as was said in discussions with English researchers. Entrant tests at the beginning of the vocational education obviously only test skills of applicants which have been trained in compulsory schooling beforehand. These tests, however, cannot be used as indicators of the mathematics needed in the jobs. The great variety of different entrant tests even points at the possibility that employers do not even know the qualifications they want from their applicants when they apply, without taking into account the qualifications the future craftsman needs in her/his job.

Looking into the results of the research work "confusion" seems to be the right description: Answers even for the same profession are contradictory, even when companies of the same size and production area are asked, or as DAWES/JESSON put it: "The analysis ... (of employers' answers what mathematics they need)

provided some indication that the mathematical needs of the young employee are not ... clearly defined by their employers. Even the 'common core' identified by KNOX can hardly be said to be 'common' ..." (DAWES/JESSON, p. 399).

Do these contradictions only indicate the deficiencies of our research methodology and questions or do they reflect a more deeply rooted mistake we make when only searching for the mathematics industry and commerce need?

3.2 The Process of Mathematization as Topic in TVE

As pointed out already earlier, apprentices have a lot of difficulties in finding the appropriate mathematics for the solution of their vocational problems. Why is this true and how can we change this state of the art?

One simply stated problem may stem from the organization of this vocational education: Having separated college and on-the-job training, the college seems to have problems in keeping step with the evolution of technology and thus in teaching the apprentice the application of mathematics to real work-life situations. The vocational problems which are to be solved in college mathematics may tend to become artificial or even old-fashioned and irrelevant to the real working life.

Besides this problem of keeping step with the evolution of technology, if not being ahead of technological progress, mathematics in TVE has not only to teach applicable mathematics, but also the process of the application of mathematics, the "mathematization-process". West-German research done in the field of application of mathematics to vocational situations (DAMEROW et al., JAEGER/SCHUPP, SCHOLZ) shows that this process cannot be described nor understood merely in terms of the mathematical discipline. Concepts as modelling, communication skills, and ccoperation with experts in other fields than mathematics are needed to understand what is going on in such a process of mathematization. I am not so fond of the often quoted circle describing the application of mathematics as the process of

problem definition - model building - building of a mathematical model - solving the mathematical model - interpreting the mathematical results in terms of the problem definition

and may-be reiterating this circle. This description, however, shows one aspect of the problem very clearly: the process of application of mathematics is not only a process inside mathematics. Mathematics plays a minor role in this business which is determined by facts and motives outside mathematics. Consequently, mathematics in TVE cannot concentrate on the teaching and learning of special mathematical topics, but also has to provide the knowledge and skill of the mathematization of a given or future vocational situation.

3.3 "Mathematical Thinking" - NOT Mathematics is Needed in TVE

In the FRG, two studies have been published concerning the way and extent probability and statistics are being used in commerce and industry (JAEGER/SCHUPP, SCHOLZ). One of them was done by interviewing workers and employees about the statistical knowledge they really needed in their jobs. The jobs to be analysed were chosen because of their numerical importance for apprentices. The other study used the case study method and analysed the extent and way in which stochastical phenomena are noticed and handled by physicians and managers of smaller branches of banks. Both studies came to the identical conclusion that it was not probability and statistics as such what is used in the vocational situations. The workers and employees used statistical techniques and concepts in a way quite different from that the discipline mathematics presents them. What they need is the overall concept of stochastical information and decision making on the basis of uncertainty, instead of special frequency distributions, probability theory or Kolmogorov's axioms.

A second evidence comes from a broader discussion about the organisation, topics and methods in TVE in the FRG: The trend seems to favor not a narrow qualification for just one special activity or job, but the preparation for whole areas of working life in order to enable workers to change their occu-

pation, their job or even the vocation. Such a broadening of the field the apprentice is trained for may urge a different mathematics education than a disciplinary one.

I have the impression that mathematics in TVE should stress the overall concepts of mathematics as numbers, functions, geometry, and stochastic thinking. Mathematics should offer basic ways of thinking as the idea of algorithm , logical reasoning, and sequential analysis. Offering these "topics" together with a deep understanding of the way, the possibilities and problems when applying mathematics to vocational situations could offer a link between the mathematics to be taught and the working situations it is needed for.

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